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Comparison of simple rectangular and slotted ground micro-strip patch antenna for WLAN

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Abstract— ***The latest wireless technology requires low cost trans-receive system, which fulfills the higher transmission and reception speed with reliable communication. A two element compact MIMO antenna is designed and simulated in CST tool. The traditional full rectangular MIMO antenna is compared with slotted ground patch. The antenna is designed to operate in a 4.6 GHz with the optimum value of the envelop correlation coefficient (ECC) and voltage standing wave ration (VSWR). The mutual coupling effects can be minimized by increasing the length of feed line and ground slots. The size 38 x 61 mm^2 is considered for designing of single patch antenna. The obtained isolation is more than 13 dB by using ground slot in proposed MIMO design. The performances in terms of E and H component of Far-field, ECC and diversity gain have been also reported. The directivity, gain, VSWR and ECC of proposed antenna are 6.5 dBi, 1 dBi, 1.1 and < 0.01 respectively. The results of rectangular patch antenna with full ground and slotted ground are presented and reported.***

***Keywords*—MIMO Antenna, ECC, Isolation, VSWR.**

I. INTRODUCTION

In modern days popularity of new services and function for mobile equipment has been increased. These new function and services need a higher data rate to work efficiently. Nowadays mobiles are coming with various facilities like GPS, Wi-Fi, Bluetooth and infrared etc. Few paper worked on wideband small size antenna with co-planer feed arrangement in orthogonal manner [1]. Some researchers discussed the concept of reconfigurable antenna for WLAN application [2]. The author discussed four port microstrip square ring patch MIMO antenna resonates at 2.4 GHz ISM band. Complementary split ring resonator loaded on its ground to improve the isolation of 22 dB and complementary split ring resonator reduces coupling about 6.5 dB between radiating elements in the reported design [3]. Some author discussed about two elements MIMO for UWB application. In this the radiator are arranged perpendicular to each other and gives isolation of more than or equal to 20 dB [4]. A UWB radiator with dual polarization diversity shows bandwidth varies 2.7 GHz to 10.9 GHz. By etching U-shaped slot on each antenna band notch is achieved from 5.1 GHz to 5.9 GHz band. The design achieves UWB orthogonal polarization. The isolation of reported design is 25 dB and radiation pattern for each port is a quasi omni-directional radiation pattern [5]. The four element antenna can be used for portable wireless UWB application. Some slot antenna placed in asymmetrical manner to achieve the higher bandwidth and good radiation properties. The isolation was achieved up to 22 dB without using any decoupling element or network [6]. The pattern diversity based MIMO antenna is also presented using capacitor [7]. The MIMO antenna with polarization diversity designed at 1.85 GHz. This design reduces ECC and increases isolation. The diversity gain is improved from 9.90 dBi to 10.0 dBi with reported technique [8]. The size minimization is achieved by the coplanar strip fed technique [9]. A compact octagonal shaped antenna Koch fractal geometry is proposed to achieve the wide band phenomenon and to minimize the size [10]. The 16 element MIMO system reported for multiband operations [11]. Author discussed a dielectric resonator antenna for LTE Band. The two feed and simple rectangular antenna used to achieve better isolation [12]. Slim disk-shaped MIMO antenna system [13], a slot resonator [14] and ring shaped radiator [15] are reported for wireless application with enhanced isolation characteristics. Some printed polarization diversity based MIMO antenna [16] and metamaterial based structure [17] is discussed to enhance the isolation. The antenna for mobile application [18] and antenna with coupling element [19] gives better isolation value. Apart from this some cavity backed MIMO antenna reported for 5.2 GHz application. Some antenna

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achieved the isolation of -15 dB [20]. Few researchers gave diversity antenna to cover WiMax band [21].

II. ANTENNA DESIGN GEOMETRY

Design Parameters- Here the design parameter for single patch is calculated. A patch antenna is operates at 4.6 GHz. The first step is to calculate the length and width of the patch antenna. These can be determined using the following equations-

For Width,

From equation (1),

$$W = \frac{c}{2f_r\sqrt{\frac{\epsilon_r+1}{2}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

For Length,

First calculate the effective dielectric constant from equation (2),

$$\epsilon_{reff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}[1 + 12\frac{h}{W}]^{-\frac{1}{2}} \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

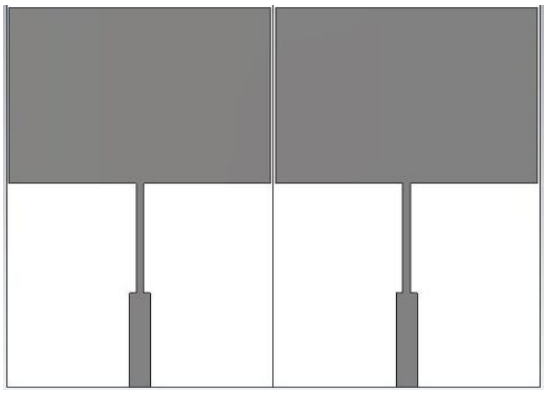
For the extended incremental length from equation (3),

$$\Delta L = 0.412\frac{(\epsilon_{reff}+.3)(\frac{W}{h}+0.264)}{(\epsilon_{reff}-.258)(\frac{W}{h}+0.8)} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The effective length can be calculated using the equation (4) below,

$$L_{eff} = \frac{c}{2f_r\sqrt{\epsilon_r}} - 2 \times \Delta L \ \ldots\ldots\ldots\ldots\ldots (4)$$

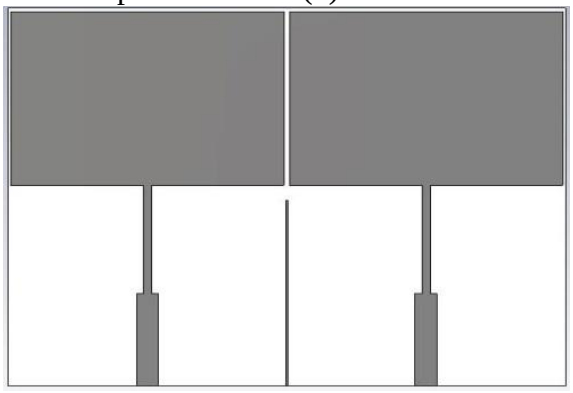
The presented design is discussed in figure 1 and 2. The complete antenna system formed of two MIMO elements printed on common FR4 substrate which has a 1.524 mm thick and a compact size of 38 × 61 mm^2. A traditional rectangular patch is selected for radiator and simple feed with 50 ohm.



(a)

(b)

Figure 1. Proposed rectangular MIMO radiator (a) Two element patch antenna (b) Ground of antenna.



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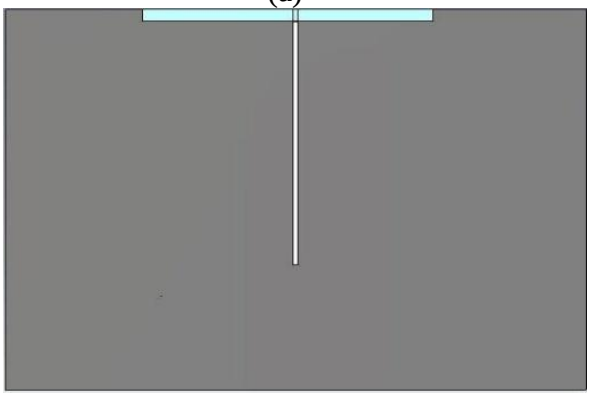

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Figure 2. Proposed MIMO antenna with PE and Slotted ground (a) Patch (b) Ground.

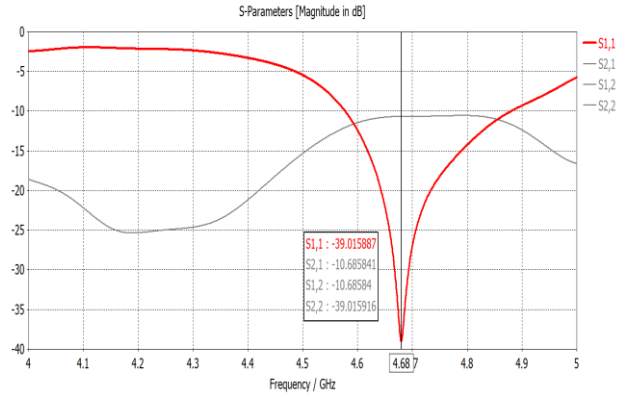
Table 1: Optimized antenna parameter of proposed MIMO antenna

Parameter	Dimension	Size (mm)
Antenna Ground	GW x GL x GH	38 x61x0.07
Substrate	SW x SL x SH	38x61 x1.524
Patch	PW x PL x PH	37.3x28 x0.07
Feed	FW x FL x FH	2.98x15x0.07
Feed 1	FW1 x FL1 x FH1	1.1x17.4x0.07

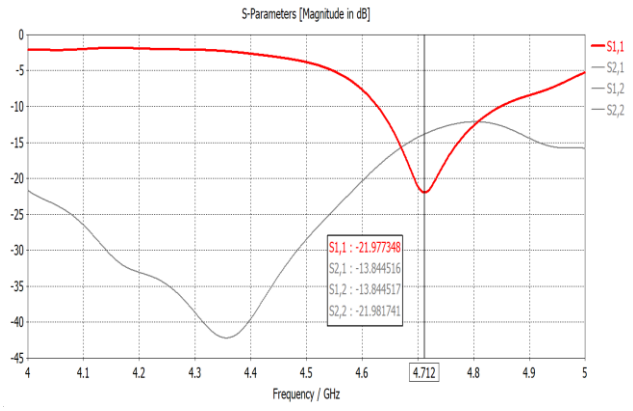
III. MIMO ANTENNA SYSTEM- SIMULATION RESULTS

The proposed geometry is simulated using tool CST. The antenna also optimized with the given tool. The antenna resonates at 4.7 GHz. The traditional rectangular patch is compared with slotted one. The figure 3(a) and 3 (b) discussed the results of both cases separately. The proposed antenna has return loss of -39 dB at 4.7 GHz with isolation greater than 10 dB in defined frequency band. The slotted arrangement with parasitic element has -22 dB return loss at same resonating frequency with isolation of greater than 13 dB in whole band.

Isolation Characteristic-



(a)

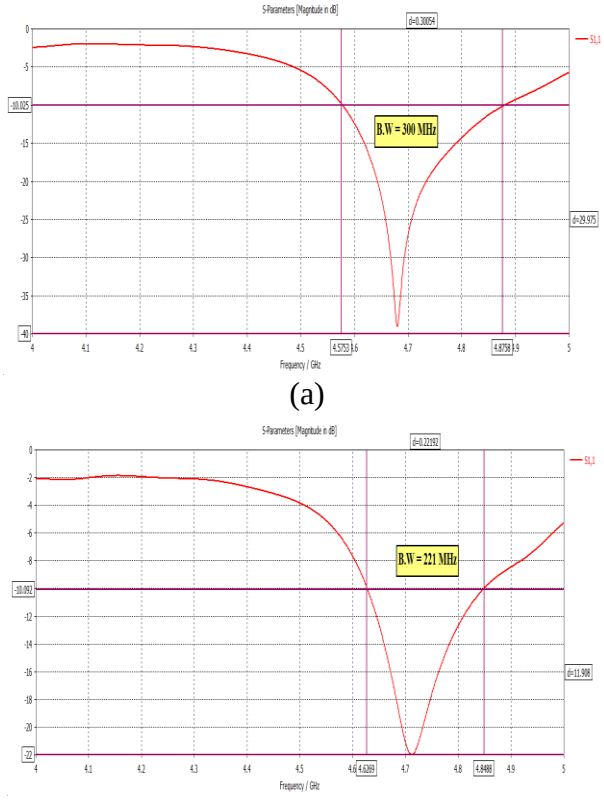


(b)

Figure 3. S-parameter of proposed MIMO antenna (a) Simple rectangular (b) With parasitic element (PE) and slotted ground.

Bandwidth characteristic-

The bandwidth of proposed simple rectangular microstrip patch antenna and antenna with parasitic element (PE) and slotted ground is presented in figure 4 (a) and 4 (b) The proposed simple rectangular antenna bandwidth is 300 MHz and bandwidth of slotted ground is 221 MHz.



(a)

(b)

Figure 4. Bandwidth of designed antenna (a) Simple rectangular (b) With PE and slotted ground.

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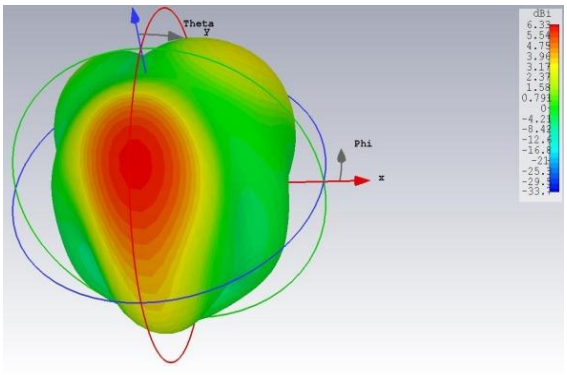
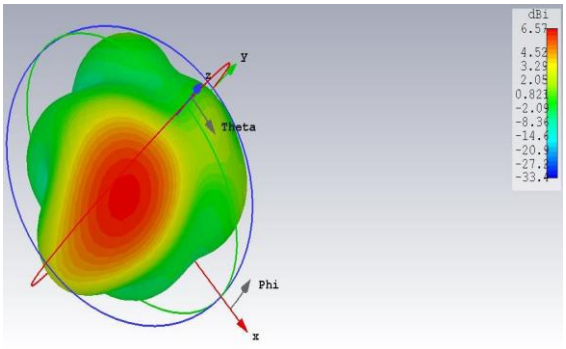
Far Field Radiation Patterns-

The normalized far-field in terms of E/H plane of 2-element are measured at 4.7 GHz resonant frequency. For 2-elements antenna, the simulated far field E and H-planes is described using E_θ and H_θ components. The directivity and gain of proposed design is presented in figure 5 and 6 respectively.

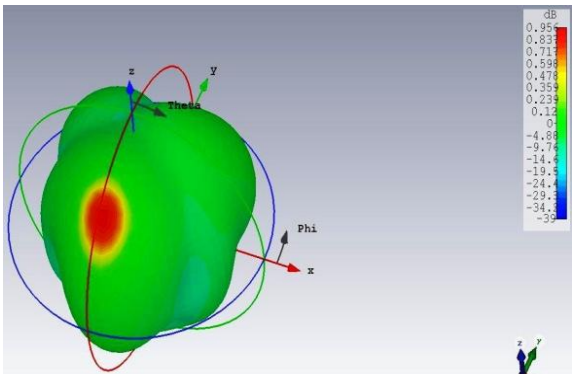


(a)



(b)

Figure 5. Directivity (a) Simple rectangular (b) With PE and slotted ground



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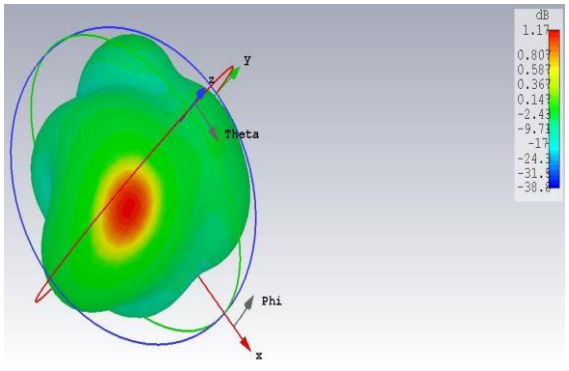
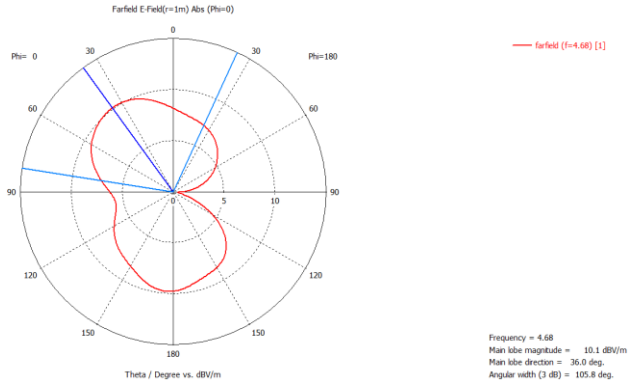


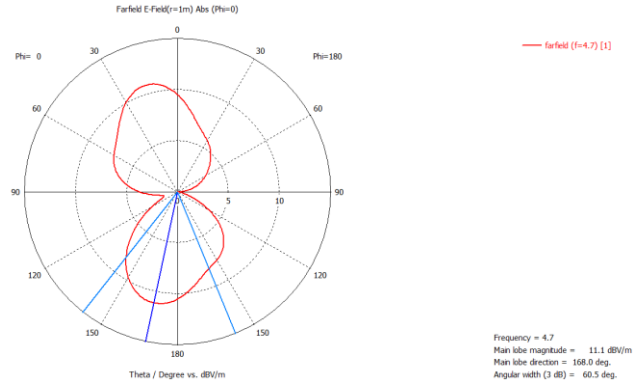
(b)

Figure 6. Gain (a) Simple rectangular (b) With PE and slotted ground.

The figure 7 given the polar plot of E-Field radiation pattern. The E field for the antenna 1 is 10.1 dBV/m, while the slotted ground antenna has maximum field is 11.1 dBV/m. The H-Field polar plot shows in figure 8. The maximum field of 36.2 dBA/m and 36.0 dBA/m are obtained for rectangular and slotted ground antenna respectively.



(a)



(b)

Figure 7. E-field of proposed MIMO antenna (a) Simple rectangular (b) With PE and slotted ground.

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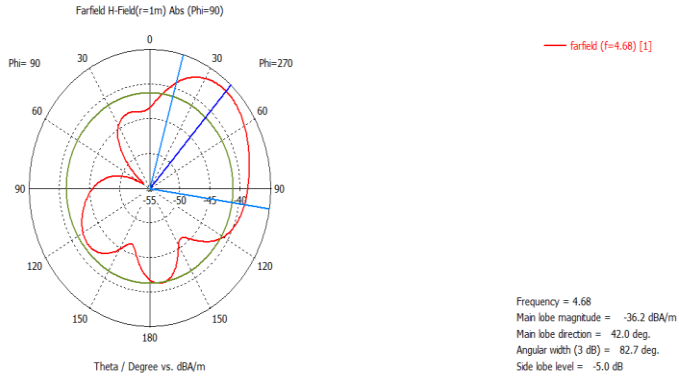
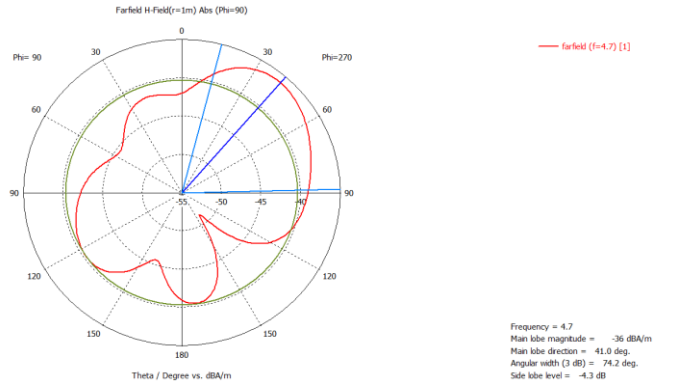


(a)

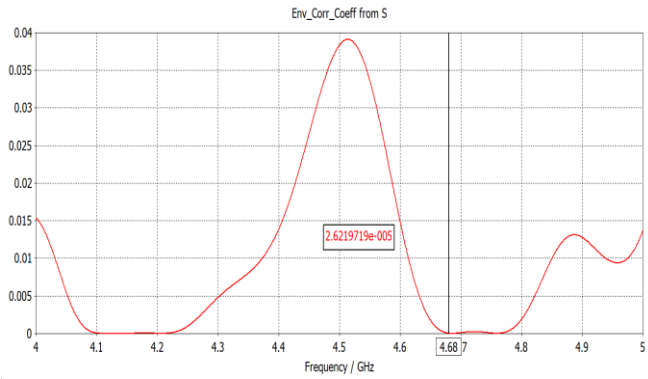


(b)

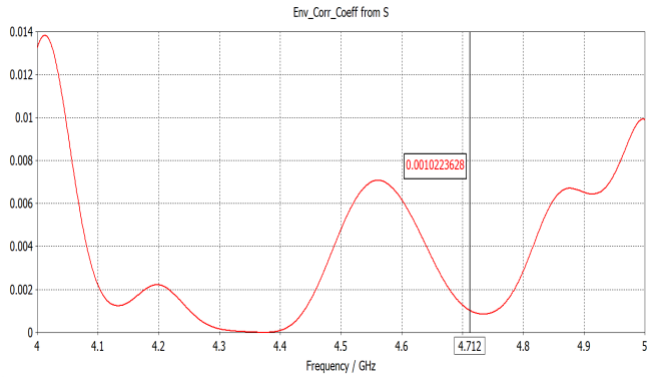
Figure 8. H-field of MIMO antenna (a) Simple rectangular (b) With PE and slotted ground.

Envelope Correlation Coefficient-

The ECC is described in figure 9. From the Figure 9, it is clear that ECC for proposed structure is less than 0.01 and ECC of MIMO antenna with PE and slotted ground is less than 0.002.



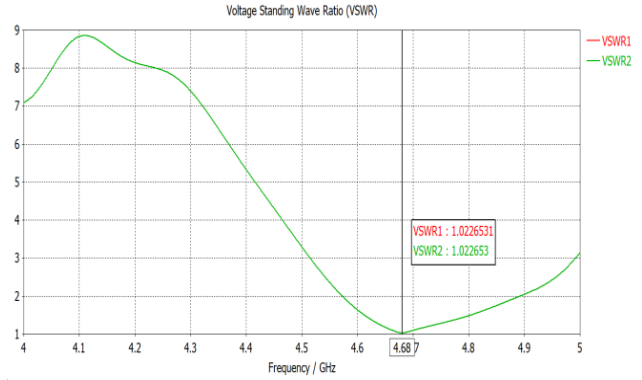
(a)



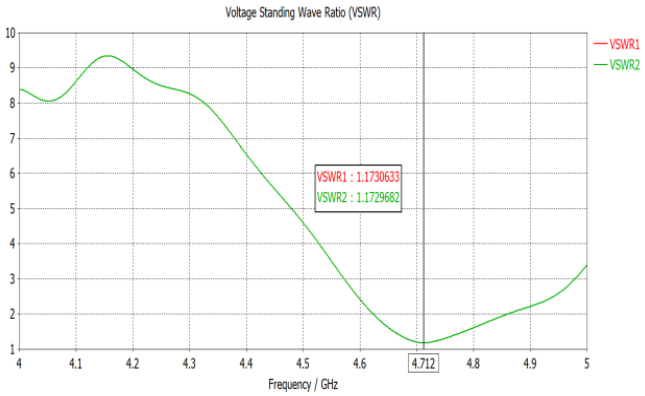
(b)

Figure 9. ECC (a) Rectangular patch (b) With PE and slotted ground

Voltage Standing Wave Ratio-



(a)



(b)

Figure 10. VSWR (a) Rectangular antenna (b) With PE and slotted ground.

VSWR represents reflected value from the antenna port. The ideal value of VSWR is 1 and it ranges from $1 \leq$ VSWR $\leq \infty$. The figure 10 shows the VSWR results and it is 1.1 at resonant frequency.

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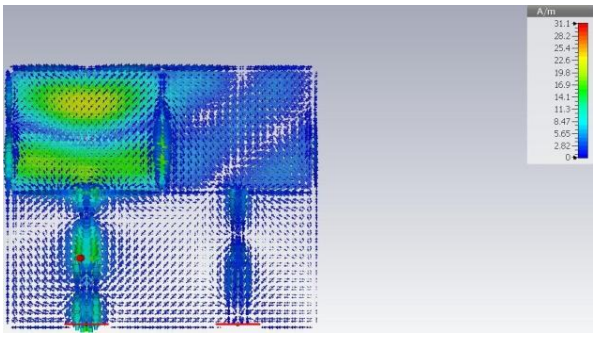
Surface Current-

The surface current distribution on antenna patch is presented. Surface current presents an analytical view of how much and how current flows in the antenna? It is also present direction of flow of current. The effect of distribution of surface current on patches can be seen when ports 1 is powered and other ports are terminated to 50Ω line.



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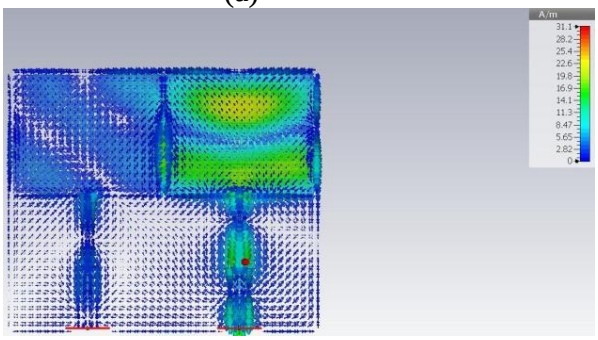
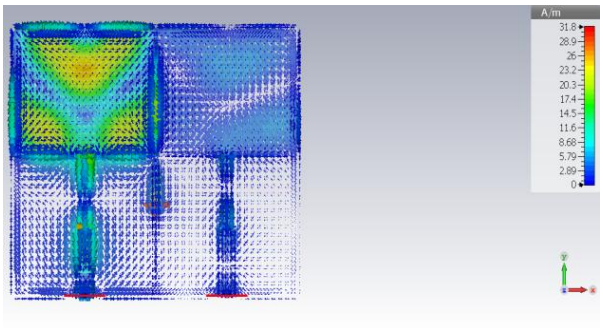
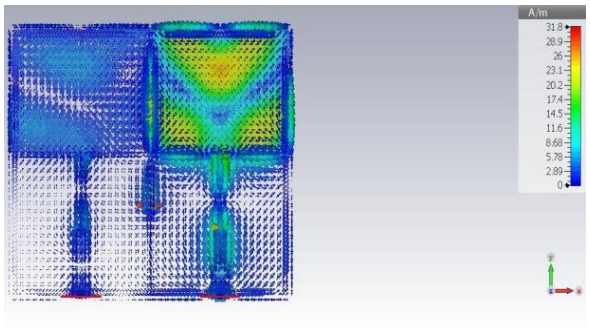


(b)

Figure 11. SCD simple rectangular (a) port-1 energized (b) Port-2 energized.



(a)



(b)

Figure 12. SCD (a) With PE and slotted-ground port 1 energized (b) port 2 is enargized.

The figure 11, and 12, shows current value on the surface of the antenna. It is shows more effect of current value in simple design antenna and a low amount of surface current can be seen in antenna design using PE.

IV. CONCLUSION

A compact 2X1 MIMO antenna is designed with rectangular geometry of full ground and slotted ground for wireless applications. The proposed MIMO antenna results are compared for full and slotted ground. The coupling among the radiator is minimizes by arrangement of slotted ground. The measured frequency bands cover the 4.57 GHz to 4.87 GHz frequency band with VSWR is less than 1.1. The overall size of the design is 38 × 61 mm^2. The obtained results show the good performance of antenna in given band. The isolation is found more than 13 dB. The simulated gain at 4.6 GHz is greater than 0.9 dB for each antenna. The ECC is found very low at resonant frequencies. The proposed MIMO geometry is suitable for wideband application. The adding slot in ground plane increases isolation performance of MIMO antenna.

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